CHAPTER I.

Problem and Method.

The problem of the present experimental study is to determine whether or not the so-called concentration of attention, or excessive attention is, as compared with normal attention, favorable to mental work. It is a common opinion that a greater amount of mental work, qualitatively or quantitatively, can be accomplished by the greater intensity of attention. This popular assumption, however, has no adequate scientific proof, and at present, a satisfactory conclusion has not been reached. It is possible that the relative efficiency of various degrees of mental concentration may vary with the kind of problem, the duration of time, and the individual's habits of work.

The importance attached to the present problem is two-fold: educational efficiency on the one hand and social efficiency on the other. The problem of the efficiency of concentration of attention has been much emphasized in modern pedagogy. Skill of teaching depends largely upon a proper control of the attentive process of school children. The present problem also has its practical value when we view it from the standpoint of social efficiency. Since modern society, as the result of division of labor, brings more monotonous work to some than to others, we must adjust ourselves by selecting the more serviceable methods for mental operations and by eliminating undesirable factors for the conservation of human energy. This thesis furnishes, to some extent, information concerning the comparative effectiveness of concentrated and normal attention in monotonous work.

The solution of the problem involves the doing of two things at the same moment, that is, the subject is required to perform the same work, or similar work of comparable difficulty, with different degrees of mental concentration, and at the same time he has to control the degree of attention while the work is being performed. If the attention is directed intensively toward the work,

the subjective control of the degree of attention may be slighted; and conversely, if it is directed mainly toward the supervision of the degree of attention, the efficiency of work may be decreased. In either case this type of simultaneous measurement presents methodological difficulties.

From the standpoint of my problem all *objective* means of measuring the degree of attention involved in any piece of work contain certain fatal defects. 1. Certain objective methods may be termed performance or achievement tests. They propose to measure the degree of attention involved in any mental task by the efficiency with which that task is performed. Two arithmetical computations are made with different degrees of attention and these two degrees of attention are measured in terms of the speed and accuracy of the two activities. Any such method cannot be utilized in our experiments, because it assumes the truth of the very proposition we propose to test. 2. The degree of attention to any act, e.g., memorizing, may be measured by means of certain activities incidental to or accompanying that act. Such incidental activities that might be used are breathing, circulation, frowning, involuntary contractions, etc. These comprise what are generally known as the physiological or expression methods. These methods again assume the truth of the proposition to be tested, viz., that a direct quantitative relation obtains between the degree of attention and any of the resulting acts even though of an incidental character. The use of these incidental acts as an index of the degree of attention assumes that these acts are conditioned by one and but one factor,—the degree of attention. 3. The only other possible objective method is to attempt to measure the attention involved in any act A through some other simultaneously induced act B. Distraction tests and Woodrow's Detractor method illustrate this class.

The former i.e., distraction method, presents some sensory stimulus to the subject while engaged in some specified task. The strength of the stimulus is increased until it attracts the attention of the subject away from the task at hand, and this strength of stimulus is regarded as an index of the degree of attention. This procedure contains several defects. The effect

on the attention is not always proportional to the intensity of the stimulus, and the effect of any given intensity may vary from time to time.

To eliminate distraction from the measurement of attention, Woodrow[1] proposes another method called "detraction." His method of measuring attention is a simple reaction using unfavorable preparatory intervals for the detractor. This means that he made a substitution of unfavorable preparatory intervals in place of some physical device, such as an alarm-bell, drugs, and other means commonly used in the distraction method.

In his experiments he obtained four different degrees of attention by using four different intensities of light stimuli; namely, bright, dim, quite dim, and very dim. He assumes that[2] "a degree in intensity sufficient to give a large decrease in reaction-time will also condition a lower degree of attention;" in other words,[3] "that the highest degree of attention would be obtained with the greatest intensity of light." It is questionable as to how far this assumption is valid. There is no objection so far as he considers a stimulus a condition of attention, but it is quite doubtful whether or not the highest degree of attention can be obtained from the greatest intensity of the stimulus. His results indicate that a greater intensity of stimulus gives a quicker reaction. But, does a quicker reaction represent a higher degree of attention? This must necessarily be true according to his assumption. Does a strong stimulus always bring forth a high degree of attention? Suppose, for instance, one sees a bright light in a dark place at one time and a very dim light at another; then, must one conclude that a strong light requires a higher degree of attention than a dim one? Or, suppose one hears two musical tones, the first is so loud that everyone can hear it in the hall, while the other is a sweet, soft, low tone; now, must one believe that the former requires, or necessarily elicits, more attention than the latter? It is clearly evident that objective means alone cannot be taken as the criteria for measuring the degree of attention.

[1] Psychol. Monog. 1914, Vol. XVII, No. 5, p. 10.
[2] *Op. cit.*, p. 71.
[3] *Op. cit.*, p. 72.

Woodrow used a simple reaction as the means of measuring attention, but there is much dispute as to the validity of its use. Some regard the speed of reaction as an index of the degree of attention, while others hesitate to do so. According to Cattell,[4] "ordinary degrees of attention do not greatly affect the length of reaction-time." Binet[5] found the same speed of reaction-time from both intelligent and dull pupils. The use of simple reaction-time as a means of measuring attention may be objectionable on the ground that it tends to become habitual.

Granted the validity of Woodrow's method, it will serve merely to measure the concentration of attention involved in reaction-time. It can hardly be used in measuring attention in some other mental work like memorizing, as in our experiments. Such a procedure would require our subjects to react to some sensory stimulus while engaged in memorizing a series of nonsense syllables. It is doubtful if one would be justified in regarding the speed of reaction-time under these conditions as an index of the degree of the attention given to the mastery of the memory-material.

As already pointed out, objective methods contain various defects for measuring attention, and hence we must search for another method which will not operate as a distraction. The method of measurement must be such that it is an integral part of the attentive work in the actual situation. The means of measurement must be found in subjective terms. This paper aims to determine whether or not a subject can estimate and compare different degrees of attention and identify each from time to time with any approximation to validity. Can one identify the stages of attention and be able to state them as greater or less just as clearly as he can recognize and describe the qualitative aspects of color, as in the case of red and green? This type of measurement implies an introspective analysis for measuring attention.

Before taking up the description of our method, it will be

[4] "Reaction-time," Mind, Vol. II, 1886, p. 238.
[5] "Attention et adaptation," Année Psychol. 1899, p. 279.

profitable to discuss at some length the experiments of Geissler and Dallenbach, for their works fall in the same line as our own.

Geissler, having become dissatisfied with previous methods, attempted to measure the degree of attention in terms of clearness value. His chief contention against the older methods was that "previous investigations had simply assumed that the variations of attention are directly paralleled by certain changes, whether in reaction-time, in muscular pressure, or in quickness and accuracy of work, etc., etc., but they had not attempted to verify this assumption by reference to experimental introspection, and thus their psychological task was only half completed." He then went on "to determine whether and how far the assumed parallelism of the expression methods rested on an experimental basis." He made experiments on motor inhibition, continuous addition, and marking circles. The last experiment was a modification of W. McDougall's method of marking irregularly colored dots or circles; it was an experiment on visual attention, and probably the best in the sense that it fulfilled more requirements for measuring attention than the other two. His subjects were required to do two things simultaneously, e.g. to estimate the degree of attention while some kind of mental work was being performed, or to estimate the quality of work in terms of clearness. The introspective analysis of the degree of attention was worked out in the following scale of nine degrees of clearness.[6]

1. About 90-100% = maximally clear or excellent attention.
2. " 80-90% = very clear or very good attention.
3. " 70-80% = clear or good attention.
4. " 60-70% = fairly clear or fairly good attention.
5. " 50-60% = fair or fair attention.
6. " 40-50% = fairly vague or fairly poor attention
7. " 30-40% = vague or poor attention.
8. " 20-30% = very vague or very poor attention.
9. " 0-20% = absolutely obscure or no attention.

Geissler thinks that[7] "the determination of a difference limen for clearness would be the most important step toward an exact measurement of concentration of attention. It would enable one,

[6] Amer. Jour., Psychol., Vol. xx, 1909, p. 511.

[7] *Op. cit.*, p. 523.

by starting with a certain clearness degree of a given mental process under fixed experimental conditions, either to increase or decrease that clearness by just noticeable differences, until the maximum or minimum of attention to the particular process is reached." In conclusion he says:[8] "a very close parallelism was found to exist between introspectively distinguishable variations of attention and the corresponding differences in the precision of work performed at these levels, under the condition that the estimation of degrees of attention was made in terms of clearness and that the work itself was not influenced by anything else but change in attention."

Psychologically, Geissler's undertaking in the measurement of attention is a promising one, but I must mention a few points regarding it. In the first place I do not agree with his identification of attention and clearness,[9] although I do admit that clearness is one of the characteristic features of attention. The introspective analysis of the degree of attention is a judicious one, but it is a method which cannot be applied to children. From a genetic standpoint, it has serious limitations and cannot be applied universally. In the second place, when we come to face the dynamic side of attention, the category of clearness tends to break down. For instance, in playing tennis, as a ball comes and goes, no one has a single moment for introspection. The degree of attention to objects in motion is hardly to be measured in terms of clearness value. Finally, the last objection, which is not so serious when compared with the other two, is found in regard to some individuals who claim to be imageless. I had one subject who classified himself with the imageless, and in such a case the category of clearness in Geissler's sense has no place.

Dallenbach's[10] work can be regarded as the continuation of that of Geissler. The former attempted to measure the degree of attention in the domain of audition, and the latter in vision. Both used the same terminology in grading the intensity of attention.

[8] *Op. cit.*, p. 529.

[9] See also Titchener, "Textbook of Psychology," p. 267.

[10] Dallenbach, "The Measurement of Attention," Amer. Jour. of Psych. 1913, pp. 466-507.

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We do not know, however, how far one can carry on the terminology of nine degrees of attention in other domains than vision and audition. Is it possible to discriminate nine degrees of clearness in touch, smell, or taste? Is it possible to differentiate nine degrees of attention in the learning process? Theoretically, there may be nine or more degrees of attention, but practically, it is almost impossible to obtain them in every individual, especially in the cases of touch, smell and taste, or in any higher mental process like learning. Furthermore, this type of technique requires a long preliminary training; for instance, one[11] of Dallenbach's subjects took three months to master nine degrees of attention in terms of clearness value.

The standardization of the degree of attention is not an easy task. From the structuralistic point of view, there may be more than nine degrees of attention, but the terms maximally clear, very clear, clear, fairly clear, fair, etc., as used by Geissler, are merely relative and may involve difficulties in identification of the varying degrees. Hence such a system can hardly be utilized up as a standard for measuring attention.

Our method of measuring attention is by no means an entirely new one, but it is an attempt to construct an adequate method for practical as well as theoretical purposes in the light of previous ones. The difference between Geissler's and Dallenbach's experiments and ours is found in two points: one is in connection with the use of technique, and the other, with the character of work chosen. As to our technique, we use but two degrees of attention, e.g. normal attention and concentrated or excessive attention. The distinction between the two is that our subjects work under two different mental attitudes: in normal attention the given task is performed with freedom and natural ease, while for the concentrated or excessive attention the greatest effort must be put forth. Two series of experiments, one for the test of normal attention, the other for that of concentration of attention, are taken in order to compare them from day to day with reference to efficiency of work. This type of technique has certain advantages over previous methods for the following reasons: (1)

[11] *Op. cit.*, p. 468.

The less the number of degrees of attention, the more valid will be the test because one can compare and identify them with greater accuracy: (2) Everyone knows what is meant by normal attention, and by concentration, and consequently the experiment does not demand a long period of previous training: (3) Such a simple technique enables us to work with children: (4) Its field of work is universal, and it allows us to work with all kinds of materials; (5) and finally, the application of its principal results has practical value for educational as well as for social efficiency.

As to the character of work chosen, our materials are such that they fulfill the following requirements necessary for measuring attention. In the first place, when the experiment requires some sort of apparatus, it must be constructed in such a way that it makes no noise. Of course, one cannot be absolutely free from internal or external distractions at any moment, but the distraction which is caused by any apparatus should be particularly avoided. In the second place, the materials for work must be such as can be completed in a short duration of time in order not to destroy the quality of attention. A short duration of time for work enables us to eliminate, or at least minimize, the effect of fatigue. In the third place, the materials must be such that they can be made equally novel and attractive from day to day. A mere repetition of the same material over and over is seriously objectionable for the measurement of attention because the act tends to become habitual. For this reason reaction-time is not suitable for measuring the efficiency of concentration of attention. In the fourth place, the organization of materials must be such that they can be made of equal difficulty. The unit of work must be clearly defined and carefully standardized; otherwise, the objective result obtained cannot be used for the comparison of different degrees of attention made by subjective estimations. In the fifth place, the materials must be of such a nature that they will permit many exercises of the same kind which will be of equal difficulty, and whose contents can be modified and varied from day to day. These five requirements are essential for any validity of results in measuring the efficiency of concentration of attention.

With these five requirements in mind, three main tasks were chosen. The first one was copying, the second one, adding, and the last one, memorizing nonsense syllables.

The description of each test at the beginning of the following chapters will sufficiently explain how each test fulfils the above conditions. It is obvious that the standardization of each unit of work is quite significant for the purpose of measuring attention.

In copying, I had ten subjects, six graduate students in the first experiment; two graduate students and two senior college students in the last experiment, including one subject whom I had used before. In addition, I had nine subjects; four graduate students in the first experiment, three of whom were used in the second experiment, and four graduate students and one senior college student in the last experiment. All of these subjects were men. In learning, I had five graduate male students, two graduate female students, and three senior college female students. Besides these adult subjects, I was privileged to use some children of the William Lay School through the kind permission of Mr. John D. Shoop, Superintendent of schools in Chicago. Ninety-six children, namely, six boys and six girls from each grade took part in our experiments for three weeks. I am very grateful to these American boys and girls who served as my subjects, patiently and cheerfully, throughout the whole series of experiments which were carried on in the spring quarter of 1917.

CHAPTER II.

The Efficiency of Concentrated Attention in Copying.

The first group of experiments concerns the relative efficiency of the two degrees of attention in copying a short series of nonsense syllables.

The general plan of constructing these syllables consisted of omitting the letter z and grouping the remaining twenty-five letters into five syllables of five letters each, rejecting all combinations obviously suggestive of meaning. Five such syllables constituted what we shall term a unit of work. Four hundred such units were constructed of such a character that no syllable was ever repeated. All units are thus highly similar. Each of the twenty-five letters appears but once in each unit. The units differed merely in the way the letters were combined.

Twenty of these units were typed on separate sheets of paper. The sheets of paper and the typewritten arrangement of the units were the same throughout. One such sheet of material constituted a day's work for a subject. The units of each sheet were divided into two equal parts. The upper half was copied with one degree of attention, while the lower half constituted the work for the other attentive attitude. The material of one of these sheets is given in Table 1.

The subject was furnished copy paper of a standard size and character. The copying was done with lead pencils and these were furnished of a standard degree of hardness. The attempt was made to keep these pencils uniformly sharp throughout the course of the experiment. The subject was allowed at the outset to arrange the two sheets of paper in reference to himself and to each other as desired, but any chosen arrangement was maintained for the rest of the experiment.

The experimenter gave a preparatory signal at the beginning of each unit of work. With normal attention the subject began copying at once. With excessive attention, a preliminary signal

TABLE 1. Specimen sheet of day's work.

Series 1 A. (For normal attention)

ewqkc	nspra	ohjld	ybmfu	txigv	fmhpe	jxayw	iborq	gudnk	vtlsc
mtxiy	hpjbg	aoveu	wrdfl	nqcks	vgflu	ixbds	cnyot	mjrkq	hwape
csknr	qawpe	hmjyo	lbufd	xtgvi	gatvs	udjni	rbqkh	yoxmw	lfcpe
lxrgi	fwbja	tcoqu	pmkdv	eyhns	pcmye	hnkof	sdwql	vuxrj	taigb
svuhd	yatnk	emqjg	ibopc	wrxfl	xwflr	bjagi	tnvdq	komcp	yhsue

Series 1 B (For excessive attention)

ruwxd	elycv	bpqat	njfso	gmhik	gnrbe	mtplu	fhqyw	ioacx	ksjvd
sihok	tvafm	gjqcd	xpynb	erlwu	rlqok	uyast	cwvxd	epfih	jbmgn
rlueb	pjngm	fiohq	aycwx	dvskt	idrlg	bvycw	tohxu	fmsep	qjank
qftbi	jmodv	asyrh	xceln	kpuwg	pkneu	ajsxw	gcmhq	lrofy	vtbdi
qjftm	nbsoa	ivekh	pxrdy	culwg	npeul	xcwkg	jrdvy	homsa	tfqbi

was given three seconds earlier to enable the subject to secure the given degree of concentration before beginning work. A short interval of a few seconds was allowed between successive units of work, while a minute intervened between the tests for the two degrees of attention. The subject was directed to secure the maximum of efficiency in speed or accuracy in every case. He was instructed to attempt to maintain the same degree of attention throughout any unit of work. In normal attention, the subject was directed to assume that attentive attitude which was most normal and customary in ordinary acts of work. In excessive attention he was instructed to work with additional voluntary effort, to assume the conscious attitude utilized in important and critical situations.

The efficiency of the work was measured in terms of speed or accuracy. The time required to copy each unit of work was measured with a stop watch. To this end the subject was instructed to give a tap with the pencil as soon as each unit was completed.

The various errors in the main belonged to one of the following classes,—omissions, insertions, transpositions, and substitutions. We attempted to work out a system of evaluating the different kind and degrees of error, but a study of the data convinced us that the kind of error was not influenced by the attentive attitude and hence such a scoring system was irrelevant to our purpose. All subjects frequently noticed errors as soon as made and corrected them. Other errors were unnoticed. Our tabular data gives the total number of errors made, those noted and corrected, and those which were unnoticed.

Experiment 1.

The first experiment consisted of two parts. In the first, twenty units constituted a day's work and the test was continued for six days. The first ten units of each day's task were performed with a normal attentive attitude, while extra effort was required for the last ten units. The subject was requested for both attentive attitudes to emphasize speed rather than accuracy. The relative efficiency of the two attentive attitudes in attaining speed must be

measured in terms of time. These time records are given in table II. The values represent the number of seconds required for each individual to copy ten units. Each series refers to a single day's record. The A series gives the values secured for normal conditions, while series B contains the records secured for excessive attention.

The second part of the experiment duplicated all of the above conditions with the exception that the subjects were instructed to strive for accuracy. The proficiency for this work must be measured in terms of error. The records are given in table III. The first column gives the total number of errors which were noted and corrected. The second column gives the total number made which were not observed by the subject. The third column gives the total number of errors made irrespective of whether or not they were detected by the subject. In the fourth column is found the average number of errors made per day together with the mean variation.

TABLE II.

Record of Time When Attention Was Directed Toward Speed.

Data	Subjects.					
	E.C.	E.S.J.	C.L.K.	J.C.P.	C.R.	L.W.W.
Series IA	104	190	195	175	217	195
Series IIA	111	181	219	173	198	188
Series IIIA	114	192	207	169	200	186
Series IVA	105	171	190	177	201	180
Series VA	102	181	178	150	200	174
Series VIA	102	180	187	154	202	171
Av.	106.3	182.5	196	166	203	182
M. V.	4.1	5.7	11.3	9.7	4.6	7.3
Series IB	106	166	194	179	171	180
Series IIB	107	183	225	167	180	169
Series IIIB	110	166	195	173	185	195
Series IVB	103	170	184	162	183	182
Series VB	115	174	174	154	175	179
Series VIB	108	120	175	142	178	180
Av.	108	163	191	163	178.6	180.8
M.V.	2.8	14.5	13.5	10.2	4.0	5.1

TABLE III.

Record of Error When Attention Was Directed Toward Accuracy.

Subjects	Corrected errors	Uncorrected errors	Total	Daily Av.	M.V.
E. C.					
Normal	17	8	25	4.2	± .96
Excessive	17	3	20	3.3	±1.1
E. S. J.					
Normal	5	17	22	3.7	±1.7
Excessive	7	6	13	2.2	± .6
C. L. K.					
Normal	15	10	25	4.2	± .8
Excessive	10	7	17	3.4	±1.7
J. C. P.					
Normal	6	38	44	7.3	±1.9
Excessive	19	33	52	8.7	±2.3
C. R.					
Normal	5	7	12	2	± .67
Excessive	11	4	15	2.5	±1.17
L. W. W.					
Normal	10	13	23	3.8	±1.5
Excessive	17	19	36	6.0	±1.3

Experiment II.

The second experiment duplicated the conditions of the previous one with the following exceptions: work extended over a period of 10 days. An alternative order between normal and excessive attention was employed. On one day, normal attention was tested first and excessive attention last. This temporal order was then reversed for the subsequent day's work. This procedure eliminated any advantage which might accrue from the temporal order in which the tests were given. As before, the experiment contained two parts: one in which speed was emphasized and one in which the attention was directed toward accuracy. The results of the experiment are given in tables IV and V.

TABLE IV.

Record of Time When Attention Was Directed Toward Speed.

A Series stands for normal attention; B Series, for excessive attention.

Data	Subjects				
	M.	C.R.	R.L.	S.	T.
Series IA	139	239	134	149	172
Series IIA	141	205	125	154	160
Series IIIA	149	204	118	135	167
Series IVA	143	179	131	138	164
Series VA	134	188	138	140	149
Series VIA	141	197	137	136	164
Series VIIA	130	197	129	132	160
Series VIIIA	136	173	130	135	168
Series IXA	138	197	131	128	171
Series XA	122	170	125	129	156
Av.	137	195	130	138	163
M. V.	5.5	13.9	4.4	6.2	5.5
Series IB	125	200	115	137	156
Series IIB	131	183	104	142	151
Series IIIB	141	187	98	137	144
Series IVB	124	167	117	129	150
Series VB	137	180	111	128	150
Series VIB	131	172	106	133	144
Series VIIB	131	148	110	124	154
Series VIIIB	123	166	111	125	154
Series IXB	145	167	112	124	147
Series XB	105	171	103	130	147
Av.	129	174	109	131	150
M. V.	8.1	10.7	4.7	5.1	3.3

Conclusions.

1. *Effort and Speed.* Extra attentive effort was effective in increasing the speed for but two subjects, E.S.J., and C.R., in the first test. The differences in speed for the other four subjects were not large enough to be significant. (See table II.) In the second test concentration was effective in increasing speed for but two of the five subjects, C.R. and T. It is to be noted that the subject C.R. gave identical results for the two conditions.

These facts indicate that any efficiency of concentration in at-

TABLE V.

Record of Error When Attention Was Directed Toward Accuracy.

Subjects	Corrected errors	Uncorrected errors	Total	Daily Av.	M.V.
M.					
Normal	20	12	32	3.2	± .88
Excessive	18	11	29	2.9	±1.58
C. R.					
Normal	8	2	10	1.0	± .8
Excessive	6	2	8	.8	± .8
R. L.					
Normal	28	17	45	4.5	±1.6
Excessive	20	4	24	2.4	±1.5
S.					
Normal	18	7	25	2.5	±1.0
Excessive	15	10	25	2.5	±1.2
T.					
Normal	16	5	21	2.1	±1.1
Excessive	18	9	27	2.7	±1.04

taining speed is limited to certain individuals, and that the comparative records as to the efficiency of the two attitudes is not influenced by the temporal order of the tests.

2. *Effort and Accuracy.* Extra attentive effort was not effective in preventing error. This fact is apparent from an inspection of the records of total error in tables III and V. No uniformity is present. In only two cases, L.W.W. and R.L. are the differences sufficiently large to approximate any degree of significance.

Neither did the extra attentive effort aid in the detection and correction of error. In no case are the differences sufficient to be significant. The ratio of errors noted for the two attentive attitudes is practically the same as the ratio of the total number made for those two conditions in eight of the eleven cases of comparison. Apparently the relative number of errors detected is primarily a function of the total made and not due to a difference of attentive attitude.

3. *Speed and Accuracy.* The attempt to increase speed as compared with that attained when the maximum of accuracy was demanded was successful with all subjects. The comparative records are given in Table VI.

TABLE VI.

Subjects	When attention was directed toward accuracy	When attention was directed toward speed	Percentage of increase
E.C.			
Normal	131	106.3	19%
Excessive	136.3	108	20%
E.S.J.			
Normal	190.5	180.5	5%
Excessive	213.5	163	24%
C.L.K.			
Normal	247.2	196	20%
Excessive	242	191	21%
J.C.P.			
Normal	203.3	166	19%
Excessive	200	163	19%
C.R.			
Normal	249	203	18%
Excessive	312	178.6	43%
L.W.W.			
Normal	249.5	182	27%
Excessive	238	180.8	24%
M.			
Normal	169	137	19%
Excessive	165	129	22%
C.R.			
Normal	207	195	6%
Excessive	259	174	33%
R.L.			
Normal	152	130	15%
Excessive	170	119	30%
S.			
Normal	164	138	16%
Excessive	168	131	22%
T.			
Normal	223	163	27%
Excessive	193	150	33%

The table indicates that the greatest increase was manifested by C.R. who secured 43% for excessive attention. The five sub-

jects E.S.J., C.R., M., R.L., S., and T. secured the greater increase in speed on the part of their excessive attention, while L.W.W. is the only subject who obtained the opposite result. E.C., C.L.K., and J.C.P. showed no difference in the percentages of increase for the normal and the excessive. The average percentages of increase for all subjects are 17% for normal and 26% for excessive attention.

The attempt to decrease the total number of errors made relative to the accuracy attained when speed was demanded was successful with ten subjects. E.S.J. was the exception. The attempt to achieve accuracy rather than speed diminished the total number of uncorrected errors with the exception of E.S.J. The emphasis on accuracy, however, did not influence the total number of errors noted and corrected. Six subjects made slightly more corrections and gave a poorer record when accuracy was requested. The number of corrections relative to the total number made (percentage of corrected errors) was increased with the exception of two individuals. The comparative records are given in table VII.

TABLE VII.

Subjects	Total errors when attention was directed to accuracy	Total errors when attention was directed to speed	No. of uncorrected errors in accuracy	No. of uncorrected errors in speed	Percentage of corrected errors in accuracy	Percentage of corrected errors in speed
E.C.	45	55	11	28	75	47
E.S.J.	35	33	13	15	34	54
C.L.K.	42	60	17	42	60	30
J.C.P.	96	101	71	83	26	17
C.R.	27	61	11	38	60	38
L.W.W.	59	78	32	60	46	23
M.	61	80	23	27	62	66
C.R.	18	54	4	30	77	44
R.L.	69	236	21	213	70	10
S.	50	70	17	43	66	38
T.	48	152	14	116	70	23

In the act of copying, speed and accuracy are generally antagonistic when either aspect is emphasized beyond the normal. Speed may be voluntarily increased but this additional efficiency

is attained by a sacrifice of accuracy. Accuracy may also be increased, but at the expense of speed. This antagonism obtained for 10 subjects. E.S.J. was able to increase speed with no loss of accuracy, or the attempt to secure greater accuracy was unsuccessful even though speed was decreased.

Speed and accuracy are independent variables however, in comparing individuals. The fastest copiers may be either the most or the least accurate of the group. Correlation values between speed and accuracy were computed by the rank method and in all six cases of comparison small positive or negative values were secured. There was no correlation between speed and accuracy measured in terms of total error, uncorrected error, or ability to detect error stated in either absolute or relative terms. The closest approximation to a valid relation was between speed and critical ability when accuracy was demanded.

4. *Individual Differences.* There are pronounced individual differences in the rate of copying when either speed or accuracy is demanded. There are also individual differences as to uniformity of speed from day to day. The mean variations representing the range of daily fluctuations are not a function of the rate. For example, E.C. is extremely fast and consistent, C.L.K. is slow but highly erratic, while C.R. is slow and consistent.

There are probably individual differences in the ability to copy accurately when either speed or accuracy is demanded. These differences of accuracy are not a resultant of differences of rate as no correlation obtains between speed and accuracy.

There is some indication of individual differences in the ability to detect errors made. When accuracy is demanded the number of errors noted is to a large extent a function of the total made. The correlation between the two is +.77. The individual differences in critical ability are thus largely a function of accuracy. When speed is demanded, there is no significant relation between errors noted and the number made. Stated in percentage terms, there are quite wide differences in the ability to note error. There is some possibility that the capacity to note error measured in percentage terms is related to the rate of copying when accuracy is emphasized.

CHAPTER III.

Fluctuations of Efficiency During Short Periods of Work.

In the experiments described in the previous chapter, subjects were required for each day's sitting to copy ten units of work in rapid succession under constant attentive conditions. Time records were taken separately for each unit. We are thus able to compare the efficiency of the work from unit to unit. On the basis of these data we propose a discussion of such temporal fluctuations of efficiency occurring in a relatively brief period of work devoted to copying nonsense syllables. For purposes of convenience we shall discuss fluctuations of speed and accuracy separately.

Fluctuations of Speed.

The data are presented in table VIII. The terms "first" and "last" in the table are the average time in seconds required in copying each of those units in a day's work. The "intermediate" values represent the average of the eight units of work between the first and the last. All the time values for the subjects belonging to group A represent an average for six days. The first and the last are thus based on an average of six units of work, while the intermediate represents the average of 48 units of work. Group B continued the work for ten days and their values represent an average of ten measurements. The first and the last terms give the average of ten units of work and the intermediate represents an average of 80 units of work.

The phenomenon of the initial spurt in the speed of copying was manifested in some degree by all subjects for both attentive attitudes. The term "initial spurt" refers to the fact that on the average the first unit for each day's work was copied more quickly than the subsequent ones.

The final spurt was manifested for both attentive attitudes by

TABLE VIII.

Fluctuations of Speed in Copying.

	Group A.				Group B.		
Subjects	First	Intermediate	Last	Subject	First	Intermediate	Last
E.C.				M.			
Normal	10.5	10.6	10.1	Normal	12.5	14	13
Excess.	10.5	10.7	11	Excess.	11.5	13.2	12.5
E.S.J.				C.R.			
Normal	17.5	18.5	17.1	Normal	17.5	19.7	19.3
Excess.	15.3	17.2	16.8	Excess.	16.2	17.6	17
C.L.K.				R.L.			
Normal	19	19.6	20	Normal	12.7	13.1	12.3
Excess.	16.8	19.4	19.8	Excess.	10	11.1	9.9
J.C.P.				S.			
Normal	16	16.7	15.8	Normal	13.7	15	14.1
Excess.	15	16.4	16	Excess.	12.4	13.2	13
C.R.				T.			
Normal	19	20.4	20.3	Normal	14.3	16.5	16.7
Excess.	16	18.1	17.6	Excess.	13.5	15.1	15.5
L.W.W.				Av. Normal	14.1	15.7	15.1
Normal	15	18.8	18				
Excess.	14.5	18.5	18	Av. Excess.	12.7	14	13.6
Av. Normal	16.1	17.4	16.9				
Av. Excess.	14.7	16.7	16.5				

nine of the eleven subjects. This term refers to the fact that the speed of the act was quickened as the last unit of each day's work was reached.

An analysis of the records for the intermediate units reveals the fact that no uniform fluctuation of speed occurred during the period.

The comparative data for the two attentive attitudes shows that the extra attentive effort was successful in increasing speed for all periods of the day's work, for eight of the eleven subjects. The initial spurt was manifested in a relatively greater degree for the excessive attentive attitude in nine of the eleven subjects, while the normal attitude was the more effective in promoting the final spurt in eight subjects. These facts indicate that while extra

effort tends to be effective throughout each day's task, yet its greater efficiency is manifested in the initial units.

There is no unanimity among writers as to the existence of the initial and final spurts. Thorndike denies the existence of both phenomena, saying:[1] "I am unable to find anywhere any evidence of a consistent initial spurt with any individual in all mental functions or with all (or nearly all) individuals in any kind of mental work." This statement seeems to be questionable, and so far as the writer sees, the phenomenon of the initial spurt may depend more or less on the kind of mental work, the duration of time and the different type of individual habits of work.

Fluctuations of Accuracy.

The previous mode of procedure was utilized in studying the temporal fluctuations of accuracy during a short period of work. Errors were recorded for each unit separately. The average error records were computed for the first, last, and the eight intermediate units of each day's work. Comparisons as to the accuracy are much more difficult than for speed because of the greater variability in the error records.

The existence of both the initial and the final spurt is indicated by the results. The average records for the two groups are given in table IX. The initial and final spurts are evident for both groups and for both attentive attitudes. The individual records are not given. However, the initial spurt was present for five of the six subjects of group A and for four of the five in group B. The final spurt was manifested by seven of the eleven subjects.

Any extra attentive effort is not uniformly successful in achieving accuracy throughout the day's work. The better average results for both groups were obtained by the excessive attitude only for the initial and intermediate periods of work. In other words, the efficiency of extra effort in achieving accuracy is confined to the initial stages of a brief period of work.

[1] "Educational Psychology," Vol. III. p. 55.

TABLE IX.

	first	intermediate	last
Group A.			
Average of Normal	.33	.47	.33
" " Excess.	.30	.39	.38
Group B.			
Average of Normal	.24	.28	.20
" " Excess.	.16	.23	.22

Conclusions.

In the act of copying the existence of an initial and final spurt in efficiency is indicated by both the speed and error records. The initial spurt is the more pronounced.

There is no evidence of any uniform temporal fluctuations during the intermediate periods.

The efficiency of any extra attentive effort in achieving either speed or accuracy is most pronounced in the initial stages of each day's work, and this initial greater efficiency tends to decrease with the duration of the task.

CHAPTER IV.

The Efficiency of Concentrated Attention in Addition.

This chapter attempts a comparison of the relative efficiency of the two degrees of attention in the task of adding columns of one-place numbers.

The following scheme was adopted in order to construct a number of standard units of work of comparable difficulty. Two such units are given in table X. Each unit consists of ten columns of ten one-place numbers so chosen that the sum of each column lies between 45 and 50 while the total sum of each

TABLE X.

Specimen Units of Work.

A

6	5	4	2	7	7	6	4	5	9
7	6	5	9	8	6	8	2	6	8
8	7	6	8	1	3	4	7	3	6
1	8	7	1	6	4	9	1	9	3
5	4	5	5	7	2	1	6	7	5
2	5	4	4	9	1	2	7	2	1
7	2	5	5	2	3	5	3	8	6
4	6	7	2	3	8	7	2	3	3
2	3	2	6	5	9	2	9	5	2
3	2	1	5	1	2	3	5	1	7
45	48	46	47	49	45	47	46	49	50

B

6	6	7	1	4	5	5	3	6	2
4	8	2	6	7	6	8	5	3	9
9	3	7	4	1	8	7	4	5	7
7	2	1	9	8	2	9	8	4	2
6	9	9	8	9	9	2	9	9	5
1	1	6	2	2	1	1	1	2	7
4	4	2	4	6	6	3	4	1	6
5	5	5	7	1	3	4	7	5	2
3	3	3	5	5	6	6	2	2	4
1	8	4	2	4	4	1	5	8	3
46	49	46	48	47	50	46	48	45	47

Sum of A = 472 Sum of B = 472 Sum of A = Sum of B.

TABLE XI.

Record of Time and Error, With Normal Attention (upper table) and Excessive Attention (lower table) to Accuracy.

	E.S.J.		C.L.K.		L.W.W.		K.	
	Time	Error	Time	Error	Time	Error	Time	Error
Series IA	397	3	330	4	460	5	494	3
Series IIA	390	2	342	2	412	6	488	4
Series IIIA	392	0	311	2	375	8	423	5
Series IVA	370	2	314	2	374	4	414	5
Series VA	385	0	308	1	381	8	429	4
Series VIA	331	3	288	2	389	3	418	6
Av.	377.5	1.7	315.5	2.17	398.5	5.67	444	4.5
M.V.	18		13.7		25		31	
Series IB	512	3	310	4	450	8	379	6
Series IIB	394	0	322	1	391	8	408	5
Series IIIB	423	2	291	3	350	9	382	8
Series IVB	383	3	295	1	348	5	399	4
Series VB	395	1	287	3	341	3	416	5
Series VIB	377	1	287	3	345	3	385	2
Av.	414	1.7	298.7	2.5	370.8	6	394.8	5
M. V.	36		11.6		33.1		12.8	

TABLE XII.

Record of Time and Error, With Normal Attention (upper) and Excessive Attention (lower) to Speed.

Subjects.

	E.S.J.		C.L.K.		L.W.W.		K.	
	Time	Error	Time	Error	Time	Error	Time	Error
Series VIIA	342	2	297	4	...	..	395	4
Series VIIIA	340	1	288	2	312	4	442	2
Series IXA	329	2	280	2	318	6	429	2
Series XA	322	3	271	0	292	2	402	3
Series XIA	320	3	268	1	345	5	397	4
Series XIIA	348	2	268	4	314	3	402	5
Av.	333.5	2.7	278.7	2.17	316.2	4	411	3.3
M. V.	10		9.7		12.2		16	
Series VIIB	335	5	264	6	...	..	370	2
Series VIIIB	315	5	281	2	347	4	417	7
Series IXB	303	3	262	3	322	3	385	5
Series XB	309	2	264	2	299	4	418	6
Series XIB	345	3	253	0	319	2	360	2
Series XIIB	314	3	265	0	322	4	397	3
Av.	320.2	3.5	264.8	2.17	322	3.4	391	4.2
M. V.	13.2		5.4		10.2		19.5	

unit is invariably 472. Some fifty of these units were constructed of such a character that no unit or column was employed twice. Two such units were typed on sheets of paper, and presented visually to the subject.

Each column was added separately and the sum recorded. The work was continuous throughout a unit, the subject beginning a second column immediately after recording the sum for the first. In these experiments the test for normal attention was invariably given first for each day's work. An interval of a minute was then allowed before beginning the test for excessive attention.

The efficiency of the work was measured in terms of speed or accuracy. The time required to complete each unit of work was recorded with a stop watch. The accuracy of the units was measured in terms of the number of columns added correctly. Thus the greatest possible number of errors per unit was ten. No attempt was made to evaluate the different degrees of error in adding a single column. A wrong total was counted as one

TABLE XIII.

Record of Time and Error, With Normal Attention (upper) and Excessive Attention (lower) to Accuracy.

	Subjects.					
	E.S.J.		C.L.K.		L.W.W.	
	Time	Error	Time	Error	Time	Error
Series IA	150	0	175	0	153	3
Series IIA	140	0	143	1	147	1
Series IIIA	164	1	148	3	152	1
Series IVA	165	0	156	0	172	1
Series VA	134	1	155	3	174	0
Series VIA	161	2	154	0	187	4
Av.	152.3	.67	155	1.17	164	1.67
M.V.	11		6.8		13.5	
Series IB	144	1	159	0	150	2
Series IIB	151	1	153	0	167	1
Series IIIB	185	2	143	0	156	4
Series IVB	179	2	170	2	161	3
Series VB	159	1	155	1	168	3
Series VIB	168	3	162	2	173	3
Av.	164.3	1.67	157	.83	162.5	2.67
M.V.	13		6.7		6.8	

error, no matter whether the recorded sum deviated from the true result by two or eleven.

The experimental conditions were varied somewhat during the progress of the experiment. 1. A day's work consisted of four units with normal attention followed by four units with excessive attention. In both cases the attention was directed toward the attainment of the maximum of accuracy. This procedure was continued for six days. These results are to be found in table XI. In these as in the subsequent tables, the term 'Series' refers to a day's work for a given attentive attitude. Those series marked A refer to the results achieved with normal

TABLE XIV.

Subjects.

Record of Time and Error, With Normal Attention (upper) and Excessive Attention (lower) to Accuracy.

	C.R.		J.C.P.		S.		Rl.		T.	
Data	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors
Series IA	59	0	96	4	73	0	59	1	93	0
Series IIA	76	1	99	3	73	2	67	1	93	4
Series IIIA	72	2	106	3	73	0	70	0	97	2
Series IVA	60	0	94	2	74	1	58	1	96	1
Series VA	57	1	97	0	70	1	75	0	86	3
Series VIA	56	0	99	1	68	1	55	0	88	5
Series VIIA	59	0	87	3	67	1	55	0	80	0
Series VIIIA	57	0	89	2	67	0	58	2	90	0
Series IXA	78	0	92	3	70	0	60	0	102	1
Series XA	79	0	94	1	70	0	63	0	85	1
Av.	65	.4	95	2.2	70.5	.6	62	.5	91	1.7
M.V.	8.7		4.1		2.2		5.4		5.2	
Series IB	74	1	105	3	75	2	60	1	92	0
Series IIB	82	1	104	0	77	1	60	0	95	0
Series IIIB	83	0	97	1	82	1	55	0	83	0
Series IVB	85	0	104	2	78	0	70	0	85	2
Series VB	82	0	108	2	72	0	72	0	83	2
Series VIB	78	0	102	2	77	0	54	0	82	1
Series VIIB	85	0	108	0	66	0	75	0	76	0
Series VIIIB	83	0	98	0	78	0	46	0	99	1
Series IXB	91	0	87	1	73	0	48	2	77	2
Series XB	77	0	92	2	78	0	60	0	81	3
Av.	82	.2	100	1.3	76	.4	60	.3	85	1.1
M.V.	3.4		5.7		3.2		7.4		5.9	

attention, while B denotes the employment of excessive attention. 2. The above procedure was now repeated with the exception that the attention was directed toward speed instead of accuracy. The results obtained are given in table XII. 3. The first procedure was duplicated except that but two units for each degree of attention constituted a day's work. These results are to be found in table XIII. 4. The third procedure was continued except that but one unit per day was given for each attentive attitude and the work was continued for ten days. The data from this test are given in table XIV.

The above variations of procedure thus consisted of altering the duration of a day's work, and the number of days over which the experiment was continued.

Conclusions

1. *Effort and Accuracy.* The results of extra attentive effort in securing accuracy in arithmetical computations are given in the comparative error records of tables XI, XII, XIII, and XIV. In table XI, effort increased the error record with three subjects and was without influence in one case. The differences are not sufficiently large to be significant. In table XIII, effort increased the error records in two cases and decreased it in the third. None of the differences are probably significant. In table XIV, effort decreased the number of errors with all five subjects. The differences in at least three cases are not significant. The fact that uniform results were obtained for all subjects indicate a possible influence of effort in decreasing error in this test.

We thus conclude that effort is not effective in securing greater accuracy in numerical computations with the possible exception for the shorter periods of work, two units per day. This possible exception indicates that the efficiency of additional attentive effort directed towards securing accuracy may be dependent upon the duration of the work and possibly upon the individual.

2. *Effort and Speed.* The extra attentive effort in securing speed decreased the average time values for three subjects and increased it for one subject. The differences are not sufficiently

great to be significant with the possible exception of one subject, (C.L.K. table XII). We conclude that effort is not effective in securing speed in arithmetical computations.

3. *Relation of Speed and Accuracy.* Any attempt, both normal and excessive, to secure the maximum of accuracy was unsuccessful. On the contrary, the error records of table XI when accuracy was emphasized are larger than when speed was emphasized, (table XII) in five out of eight comparisons. However, the differences are probably not large enough to be significant. The unsuccessful attempt to secure a greater amount of accuracy resulted in a diminution of speed for all subjects. The differential results are significant for three of the four subjects. These time differences may be due in part to practice.

Stated in opposite terms most attempts to secure speed are successful without any loss of accuracy, but the attempt to secure accuracy is unsuccessful even though speed is sacrificed. The maximum amount of all-around efficiency in numerical computations is thus secured by emphasizing speed rather than accuracy.

4. *Individual Differences.* There are some individual differences in both speed and accuracy which are large enough to be significant. The differences are largest in table XI and smallest in table XIII, which fact indicates that the individual differences tend to disappear with practice. Individual differences are again apparent in table XIV when a new group of subjects was employed

There is no necessary antagonism between speed and accuracy in comparing individuals. Subjects L.W.W. and K. are comparatively slow and inaccurate (XI-XIII). The same statement is applicable to J.C.P. and T. in table XIV. However, there is no exact correlation between speed and accuracy. C.R. is the most accurate of his group but not the fastest. C.L.K. is speedier than E.S.J. but is not consistently the more accurate of the two.

The individual differences as to variability in time are to some extent a function of the absolute time values. The largest m.vs. are associated with the largest average time values in six of eight comparisons. The least m.vs. are associated with the smallest

averages in five of eight comparisons. There are probably some individual differences in consistency.

5. *Efficiency and length of task.* The speed of adding is a function of the length of the daily task when the maximum of accuracy is demanded. The shorter the task, the greater is the speed with which it is performed. The average times in seconds required by an individual to add a unit of work were 94.2, 79.6, and 78.6 when the daily work consisted of 8, 4 and 2 units respectively. These values are based upon the records of tables XI, XIII, and XIV. The differences between these values can not be due to practice as both groups in the first and third tests were unpracticed, and the first group completed more than twice the work done by the second group. Practice may have contributed in part to the low values in the second test, but the initial speed in this test was much faster than the final speed of the first test.

There is no evidence that the number of errors per unit depends upon the length of the day's task. The average number of errors per unit were .91, .72, and .87 when the daily task consisted of 8, 4 and 2 units. The low values of the second test may be due in part to practice and in large part to the fact that the poorest subject in the first test did not continue his work in the second test. Eliminating the record of this individual, the two values are .81 and .72.

The greater speed for a short task can be explained on the same basis as the phenomenon of the final spurt. When the task is long, the subject conserves his energy and goes slow. With a short task, on the contrary, the subject tends to work with the maximum of speed.

6. *Practice Effects.* In the first test (table XI) all subjects increased their speed during the six day's work. Comparing the records for the first and the last halves of the test, the time values were decreased by about 10% on the average. A further improvement by those subjects during the second test (table XII) was not so evident, while no improvement was manifested during the third test by those subjects who continued the experiment.

The record of this group indicates that practice is quite effective in increasing the speed of adding, but that this effect is limited to the first six days, when eight units constitutes a day's task. Improvement in speed was also manifested by the second group (table XIV). Comparing the records for the first and last halves of the test, four of the five subjects increased their speed by 4% to 5%. The smaller improvement of this group may be due in part to the lesser amount of work, for this test utilized but 20 units as compared with 48 for the first group.

No assertions as to improvement in accuracy can be made for the individuals owing to the high degree of variability in their error records. Taking the records for the group as a whole and making comparisons as formerly, similar results are obtained. The first group decreased their error record by 30% during the first test, by 12% during the second test, but manifested no further improvement during the third test. The second group also manifested considerable initial improvement. It is probable that considerable initial improvement in both speed and accuracy may result from practice.

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CHAPTER V.

The Efficiency of Concentrated Attention in Memorizing.

The third group of experiments proposes to determine the relative efficiency of the two attentive attitudes in memorizing. Educational theory has assumed that the speed and efficiency of learning is directly proportional to the degree to which the mind is concentrated on the task at hand. The ability to develop and maintain a high degree of mental concentration has been regarded as one of the essential characteristics of an ideal student. This popular belief is illustrated by the following quotation from Meumann:[1]

"A first point which concerns us in learning is the regulation of attention. The attributes of attention which have chiefly to do with learning and retention are intensity and uniformity of concentration throughout the whole act of learning, and particularly persistence of attention throughout. . . . The more intensively a person concentrates his attention upon his act of learning, the sooner will he succeed, as a rule, in memorizing."

We utilized the method of paired associates. Five pairs constituted a unit of work. The following kinds of material were constructed and utilized in the tests: 1. In twenty units, the first or stimulus term consisted of two letters,—a consonant and a vowel. The second or response term was an arbitrary symbol constructed of three short straight lines. No term appeared twice in the twenty units. 2. The stimulus term was a word of four letters, while the associate to be recalled was an arbitrary symbol composed of four straight lines. One half of the words were concrete and the other half abstract. Ten units were used and no word or symbol occurred twice. 3. The stimulus term was an ordinary nonsense syllable of three letters, while the second term was an arbitrary symbol of four straight lines. Ten units were constructed in which no term was used twice.

[1] "The Psychology of Learning," p. 279.

Illustrative specimens of these three types of material are given in fig. 1.

For subjects we employed a group of ten adults, all of whom were either graduate or senior college students. In addition we tested a group of twelve children from each of the eight grades of the William Lay School. For our conditions the material proved too difficult for the first four grades; the amount reproduced was so small that comparisons as to the relative efficiency of the two attentive attitudes were valueless. Our tables thus give the comparative data only for the fifth to the eighth grades inclusive. These children were selected by the teacher in charge from those who volunteered their services.

We presented the materials to the adult group by means of a tachistoscope projection apparatus in which the pairs were projected on an illuminated ground glass screen. The pairs of each unit are exposed in rapid succession, the time of exposure for each pair being three seconds. Each unit was presented but once, and the amount memorized was tested by an immediate graphical reproduction. In the reproductive test, the stimulus terms were presented as before. Each subject of this group was tested separately.

For the groups of children, each pair was printed on a card in large bold-faced characters. The stimulus term of each pair was printed on the back of each card. The children were tested in groups. The experimenter arranged the cards in bunches of five. Each bunch was placed against a screen on the desk. The front or visible card was allowed to fall after the proper exposure, the five pairs thus being exposed in succession. The pairs were presented in immediate succession, each card being visible for three seconds. Each unit was presented but once, and the amount memorized was tested by immediate graphical reproduction. For the reproductive series the cards were rearranged, and the backs of the cards on which the stimulus terms were printed were exposed as before.

The following system of scoring was adopted in order to measure the amount reproduced. 20% was allowed for a perfect reproduction of each of the five symbols constituting a

Fig. 1. Specimens of three types of memory material.

unit. 10% was allowed if a symbol was reproduced with the wrong associate. A symbol reproduced upside down was scored 10%. 10% was deducted when one of the lines of the symbol was drawn incorrectly. 5% was deducted when any line was either over or under drawn.

Two main experiments were performed. 1. The first concerned the relative efficiency of the two attentive attitudes. The first type of material was employed. Two units were given each day: the first was studied during one exposure with a normal attentive attitude, and the amount learned was tested by graphical reproduction. After a two-minute interval a second unit was employed for excessive attention. This procedure was continued for ten days. For the first five days the reproductive order of the pairs was the same as that of their first presentation. In the second half of the experiment, the order of the pairs in the reproductive series was different from that of their presentation. 2. In the second experiment we tested the value of meaning as a suggestive or stimulus term, when the term to be recalled is meaningless. For the purpose we utilized the second and third types of material. In both types, the second or reproduced term is an arbitrary symbol composed of four straight lines. The two types differ only in the first or cue-word; in one it is a nonsense syllable and in the other, a word. Comparisons of the amount reproduced in each case will determine whether or not a meaningful stimulus cue is more suggestive than a meaningless one. Two units per day were given, first one of type 2, and then one of type 3. Each was presented once and studied with the excessive attentive attitude. The amount learned was tested immediately. The reproductive order of the pairs was different from the order in which they were presented. The test was continued for ten days. For the first five days the meaningful cue-word was concrete, while in the latter half of the test, the cue-word was abstract.

Conclusions.

1. Normal and excessive attention did not differ in effectiveness for the adult group. The average percentages of reproduction for normal and excessive attention were 81.6 and 82.3 respectively. Eight of the ten subjects gave slightly better records for the effortful attitude, but the differences are too small relative to the daily variations to be significant. No subject manifested any pronounced daily consistency in preferring one of the two attitudes. One individual gave the better record for the normal attitude for seven of the ten days while another individual gave a like preference for the excessive attitude.

2. There is some indication that normal attention is more effective with children. The average percentages of reproduction for the four grades are given in table XV. The normal attitude gave the better results for all grades.

TABLE XV.

The Average Percentages of Reproduction in Children.

	8th grade group	7th grade group	6th grade group	5th grade group
Normal	60.65	53.04	48	38
Excessive	58.88	45.3	41	32.5
Difference	1.77	7.74	7	5.5

Thirty-five of the forty-eight subjects gave a better average reproduction score for the normal attitude. When we examine the individual records we find that for the majority of subjects the average scores for the two attitudes are not sufficiently different relative to the high mean variability so that any assertions can be made as to the relative efficiency of the two conditions. Neither do most individuals exhibit any consistency from day to day in making a larger score for one attitude. Of the total group of forty-eight subjects, we give in table XVI the list of those whose records give the most indication of the influence of the attentive factor. This table gives for the two attentive attitudes, the daily percentages of reproduction, the average percentage score and the mean variation. One subject gives the best record for excessive attention, and eight for the normal attitude. All exhibit some degree of daily consistency.

TABLE XVI.

N stands for Normal Attention, E for Excessive Attention. Absences are Indicated by Blank Lines.

	1	2	3	4	5	6	7	8	9	10	A.V.	M.V.
C.M.												
N.	50	20	55	75	40	30	35	35	20	40	40	12
E.	50	20	40	30	30	35	30	30	0	35	30	8
A.B.												
N.	25	30	20	25	80	30	50	50	30	20	36	14.4
E.	35	30	0	35	30	20	20	40	0	15	22.5	11.5
G.K.												
N.	20	35	60	30	40	20	..	..	..	..	34	10.8
E.	15	10	0	40	30	10	..	..	..	..	17.5	11.6
C.W.												
N.	50	45	60	75	55	100	40	80	..	40	60.5	15.7
E.	55	30	40	60	50	20	60	60	..	10	43	15.8
S.C.												
N.	60	60	45	75	60	70	60	45	20	55	55	11
E.	55	40	35	80	60	35	30	30	30	30	42.5	13.5
F.E.D.												
N.	65	30	..	80	..	60	40	..	40	40	50.7	15.1
E.	35	30	..	30	..	10	35	..	45	40	32	7.6
D.R.												
N.	40	60	30	70	60	..	..	..	..	..	52	13.6
E.	25	30	10	35	60	..	..	..	..	..	32	12.4
M.J.												
N.	60	60	65	90	90	70	50	..	..	..	69.3	12
E.	60	50	65	70	70	60	50	..	..	..	60.7	6.5
D.P.												
N.	60	50	50	70	..	..	..	40	50	40	51.4	7.7
E.	80	60	65	80	..	..	..	60	50	50	63.5	9.7

3. In the grades, the girls gave better average records than the boys for both attentive attitudes. There was no sex difference in the adult group. The number of the two sexes were equal for all five groups. The comparative records are given in table XVII.

TABLE XVII.

The Average Percentages of Reproduction for Both Sexes.

			8th grade		7th grade		6th grade		5th grade	
Sexes	Men	Women	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Normal	81.5	81.5	59.5	61.5	50.6	51.5	43.5	52	36.8	39.8
Excessive	83	83	57	60.5	41.5	49	41	52.5	32.2	33.3

4. The irregular order of reproduction tends to decrease the

efficiency of reproduction as compared with the regular order of exposure. The fifth grade group is the only exception to this rule, for it shows no difference for the two procedures. Table XVIII gives the average percentages of reproduction for both the regular and the irregular exposure. There is no evidence that the disconcerting effect of irregular exposure varies with age.

TABLE XVIII.

The Relative Efficiency of Regular and Irregular Presentation

	Normal		Excessive	
Subjects	Regular	Irregular	Regular	Irregular
Adults	82.5	80.7	85.7	80.7
8th grade	62.6	58.7	60.75	57
7th grade	57.75	48.3	47.9	42.7
6th grade	55	41	52.5	40
5th grade	38	38	32	33

5. The effect of meaning upon the memorizing process is clearly brought out by the second part of the experiments in this chapter. Learning artificially constructed characters by meaningful association is decidedly favorable over against learning them by nonsense syllables. There is no evidence that the value of meaning either increases or decreases with age in any regular fashion. The average percentages of reproduction for the meaning and nonsense series are found in table XIX.

TABLE XIX.

The Influence of Meaning in the Memorizing Process.

	Meaning	Nonsense
Adults	80.7	65.45
8th grade group	52.87	41.87
7th grade group	50.45	32.85
6th grade group	36.12	23.5
5th grade group	25.62	18.75

6. In the meaning series, concrete words are more effective in reproduction than abstract ones. This fact is observed for both adults and children. There is some indication that the relative efficiency of concrete words becomes less with age. Table XX gives the average percentages of reproduction for concrete and abstract words.

TABLE XX.

The Relative Effect of Concrete and Abstract Words in Memorizing Process.

	Concrete	Abstract
Adults	87.9	73.5
8th grade group	54	51.75
7th grade group	59	41.9
6th grade group	45.25	27
5th grade group	30.75	20.5

7. Memory grows with age for all materials. Tables XVIII, XIX, and XX show that the memorizing process is a gradual development. Take, for instance, the meaning series of table XIX, the average percentage of reproduction of adults is 80.7; that of the 8th grade group is 52.87; that of the 7th grade group is 50.45; that of the 6th grade group is 36.12; and finally, that of the 5th grade group, 25.62. Thus the average percentage of reproduction becomes smaller and smaller as the grade becomes lower.

CHAPTER VI.

Summary and General Conclusions.

1. *Attentive Effort and Efficiency.* Educational theory has frequently assumed that the efficiency of work can be materially stimulated by the teacher by the demand for extra attentive effort on the part of the students. Teachers are prone to demand that students pay extra attention to their tasks, to work with effort or a high degree of mental tension. Mature students likewise assume that they can increase their efficiency by voluntary effort, by an attitude of mental tension, or in popular language, by voluntarily concentrating their attention on the task at hand.

It has been our purpose to test the validity of this assumption in three types of activity. Subjects were requested to perform tasks of equal difficulty with two different mental attitudes, their customary or usual attitude, and one representing a high degree of mental effort and attention.

In copying, effort increased speed with certain individuals, and the maximum of effect was secured in the initial stages of each day's work. There was no conclusive evidence that effort operated to decrease the number of errors or to aid in their detection. There was some indication that effort might be effective in preventing errors in the initial stages of each day's task.

In addition, effort failed to increase speed with the possible exception of one subject. It operated to increase accuracy for some subjects when the day's work was quite short. This fact tends to confirm the conclusion concerning copying,—that the efficiency of effort was confined mainly to the initial stages of each day's work.

In memory, effort was without effect for adult subjects, and it was possibly detrimental for some of the children.

The effect of any extra mental effort voluntarily aroused or stimulated by the experimenter is a function of the individual, his age or experience, and the kind of work and its duration.

The results thus disprove the assumption in the main. Voluntary effort made under conditions such as these in this experiment (comparable with many situations in school and industrial

life) may be slightly stimulating in limited circumstances, but it is doubtful if the extra efficiency attained will compensate for the additional energy and strain expended. This unusual mental strain is probably disconcerting and distracting with some children simply because it is unusual.

2. *Speed and Accuracy.* It has generally been assumed that speed and accuracy of work are antagonistic, that those conditions which favor speed are detrimental to accuracy and *vice-versa*. Our results fail to support this assumption ***in toto***.

In the act of copying, speed and accuracy were antagonistic for ten of the eleven subjects when either was voluntarily emphasized. One subject was able to increase speed voluntarily without any sacrifice of accuracy. There was no antagonism, however, between speed and the tendency to notice and correct the errors made.

In making additions, speed and accuracy were not antagonistic when either was voluntarily emphasized. All subjects could increase speed without any sacrifice of accuracy, but the unsuccessful attempt to increase accuracy involved a diminution of speed.

The divergent results in copying and addition may perhaps be attributed to the more familiar and habitual character of the latter process. The former being less fully automatized is more susceptible to disturbance by shifts of attention.

Speed and accuracy are not antagonistic, however, in relation to an individual's normal habits of work. They are in fact, independent variables for both copying and adding. Speedy individuals may or may not be accurate, while relatively accurate subjects may be either slow or rapid workers.

It is evident that no simple relation obtains between speed and accuracy applicable to all conditions. Rather it is to be surmised that the relationship is quite complex, varying with numerous conditions.

3. *Initial and Final Spurt.* In copying, the phenomena of an initial and end spurt are manifested in both speed and accuracy. The initial spurt is generally more dominant. The records of the group average indicate that there is no uniform temporal fluctuation during the successive intermediate periods.

4. *Efficiency and Length of Task.* Efficiency in the speed of adding depends on the length of the daily task. The shorter the task, the greater the speed. There is, however, no evidence that within our limits of work the number of errors per unit is proportional to the length of the day's task.

The greater speed for a short task may be due to caution on the part of the subject. He tends to go slow or fast in accordance with the longer or shorter length of the work.

5. *Practice Effects.* The record of speed in making additions for the two groups indicates that the effect of practice was limited to the first few days of work. No further improvement was manifested continuously. The same tendency was also shown in the act of copying.

It is difficult to determine whether or not under these conditions practice is an aid to accuracy, owing to the high degree of variability in the error records, although there is some indication similar to the case of speed.

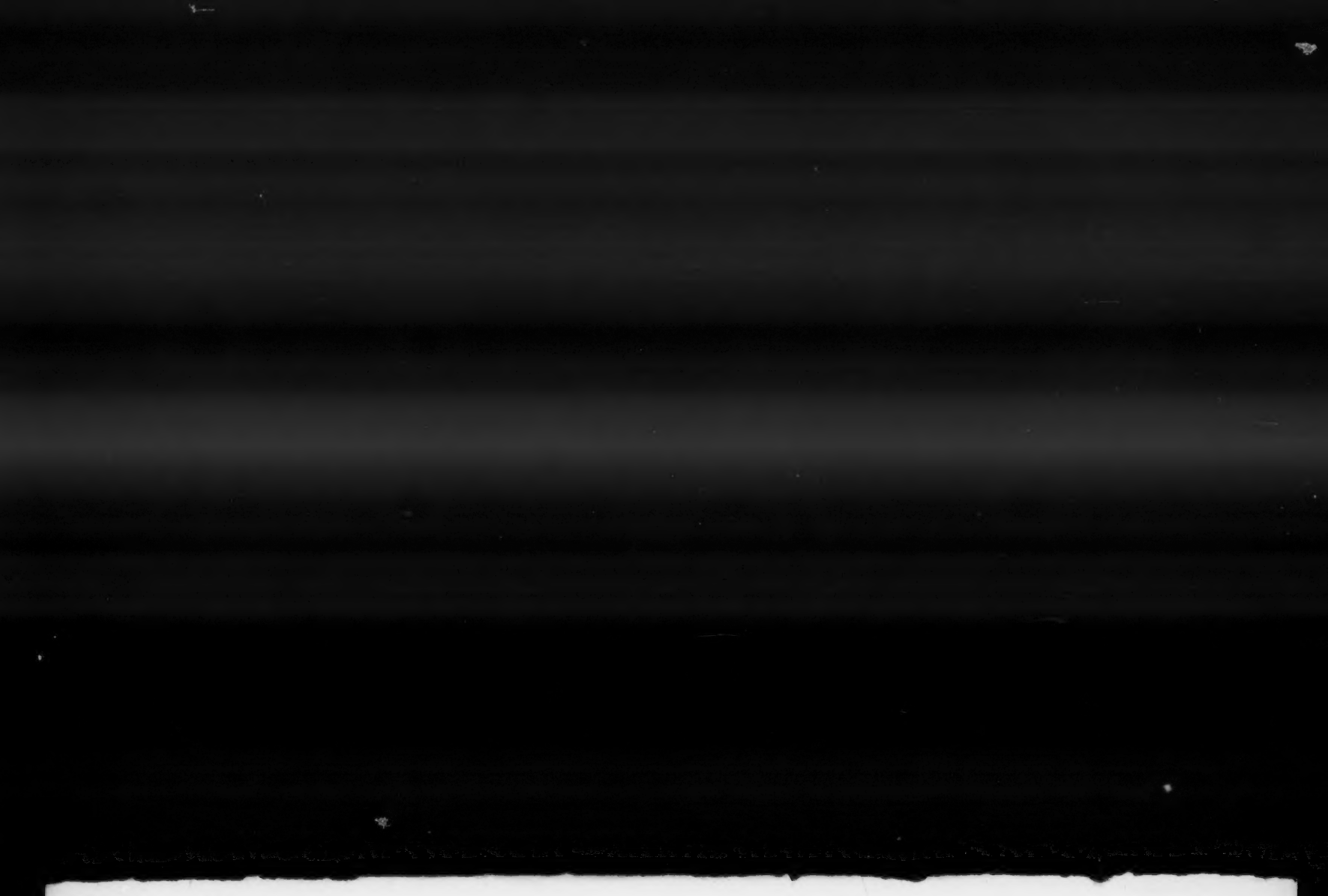
6. *Memory and Efficiency.* In our experiments memorizing processes reflect the following influences:

a. Age is one of the important factors in determining the relative effectiveness of reproduction. Our results clearly indicate that the average percentages of reproduction increase as the average ages advance up to maturity.

b. Sex is another factor affecting the relative efficiency of recall, especially with children. On the whole the girls secured better records than the boys. No sex difference was manifested in the adult group, since men and women obtained equal percentages of recall.

c. The order of exposure affects the efficiency of memory. The regular order of exposure is more effective in reproduction than the irregular order.

d. Meaning in memory, as is generally recognized, is decidedly significant. The high percentages of reproduction for meaning series and the lower percentages for nonsense series are definitely observed in both adults and children. In the meaning series, concrete words, which aid vivid impression and rapid association are more effective in the mental activity of recall than abstract words.



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